

# LASER DIODE DRIVING DEVICE

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

5           The present invention relates to a laser diode driving device for an optical disc.

### 2. Description of the Related Art

10           FIG. 4 shows an example of a conventional laser diode driving device (e.g., see JP 63 (1988)-143887 A). In FIG. 4, an input PchMOS transistor 105 constituting a mirror circuit of a PchMOS transistor is connected to a pull-in type constant current source 103 through a switch 104, and an output PchMOS transistor group 106 constituting the mirror circuit of the PchMOS transistor 105 is connected to a laser diode 107.

15           When the switch 104 is closed, an output current that is a gain-fold of the mirror circuit flows to the laser diode 107. On the other hand, when the switch 104 is opened, the output current flowing to the laser diode 107 stops flowing.

20           However, with the above-mentioned conventional configuration, the following problems arise.

          In general, the drive current of a laser diode is large. Therefore, the size of the output PchMOS transistor group 106 constituting the mirror circuit of the PchMOS transistor is large. Because of this, the gate capacitance of the PchMOS transistor is large, which makes it impossible to  
25           decrease a gate potential abruptly when the switch 104 is closed. Consequently, the rising time of the drive current of the laser diode 107 is long. Furthermore, when an input current is decreased so as to adjust a light-emission power of the laser diode 107, the rising time of the drive current of the laser diode 107 is long. In contrast, when the switch 104 is  
30           opened, the gate potential does not rise abruptly, so that the falling time of the drive current of the laser diode 107 is long.

          Recently, the storage capacity of an optical disc is increasing. In order to further increase the storage capacity in such a situation, it is necessary to shorten the rising time and falling time of a drive current of a  
35           laser diode. However, the difficulty in accomplishing this makes it difficult to increase the storage capacity of an optical disc in the above-mentioned conventional laser diode drive device.

## SUMMARY OF THE INVENTION

Therefore, with the foregoing in mind, it is an object of the present invention to provide a laser diode driving device that enables an abrupt rising  
5 time and falling time of a drive current of a laser diode.

A laser diode driving device of the present invention includes an input constant current source, a switch, and a laser diode drive current amplifier. The laser diode driving device of the present invention further includes a first differentiation circuit that differentiates a control signal of the switch, a first  
10 voltage (V)–current (I) conversion circuit that receives an output signal from the first differentiation circuit and outputs a current with the same polarity as that of the input constant current source; a second differentiation circuit that differentiates a signal with a polarity opposite to that of the control signal of the switch; and a second V–I conversion circuit that receives an  
15 output signal from the second differentiation circuit and outputs a current with a polarity opposite to that of the input constant current source.

This enables an abrupt rising time and an abrupt falling time of a drive current of a laser diode.

These and other advantages of the present invention will become  
20 apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram showing a basic configuration of a laser  
25 diode driving device according to one embodiment of the present invention.

FIG. 2 is a circuit diagram to illustrate further the circuit in FIG. 1.

FIG. 3 is a timing chart of a signal waveform of each portion in the circuit shown in FIG. 1

FIG. 4 is a circuit diagram of a conventional laser diode driving  
30 device.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be described by way of an illustrative embodiment with reference to the drawings.

35 FIG. 1 is a circuit diagram showing a basic configuration of a laser diode driving device according to one embodiment of the present invention. In FIG. 1, portions having the same configurations and functions as those in

the conventional example shown in FIG. 4 are denoted with the same reference numerals as those therein. Reference numeral 10 denotes a laser diode drive current amplifier, 11, 15 denote driving circuits, 12, 16 denote differentiation circuits, 13 denotes a pull-in type V-I conversion circuit, 17 denotes a push-out type V-I conversion circuit, and 14 denotes an inverting circuit.

In the above-mentioned circuit configuration, when a switch 104 is closed, a current of an input constant current source 103 is input to the laser diode drive current amplifier 10. A control signal of the switch 104 is differentiated by the differentiation circuit (first differentiation circuit) 12 via the driving circuit 11, is input to the V-I conversion circuit (first V-I conversion circuit) 13 that outputs a current with the same polarity as that of the input constant current source 103, and its output current is input to the laser diode drive current amplifier 10 as a differentiated current in a pull-in direction. Consequently, the rising of the laser diode drive current becomes abrupt.

On the other hand, when the switch 104 is opened, the current of the input constant current source 103 stops flowing to the laser diode drive current amplifier 10. The control signal of the switch 104 is differentiated by the differentiation circuit (second differentiation circuit) 16 via the driving circuit 15, is input to the V-I conversion circuit (second V-I conversion circuit) 17 that outputs a current with a polarity opposite to that of the input constant current source 103, and its output current is input to the laser diode drive current amplifier 10 as a differentiated current in a push-out direction. Consequently, the laser diode drive current amplifier 10 is turned off abruptly, whereby the falling of the laser diode drive current becomes abrupt.

FIG. 2 is a circuit diagram to illustrate further the circuit in FIG. 1. As shown in FIG. 2, the driving circuit 11, the differentiation circuit 12, and the V-I conversion circuit 13 shown in FIG. 1 include a NPN transistor 108 and a driving circuit 112. A collector of the NPN transistor 108 is connected to an input terminal of the input PchMOS transistor 105 constituting the mirror circuit of the PchMOS transistor, an emitter thereof is grounded, and a base thereof is connected to one electrode of a capacitor 111. An output terminal of a driving stage in the driving circuit 112 is connected to the other electrode of the capacitor 111.

In the above configuration, when the switch 104 is closed, an input terminal of the driving circuit 112 is turned to be a "High" level. The NPN

transistor 108 is supplied with a base current as a differentiated current through a capacitor 111, whereby the NPN transistor 108 is turned on. A collector current of the NPN transistor 108 is added to an original input current of the pull-in type constant current source 103 as a differentiated  
5 current, and the mirror circuit of the PchMOS transistor is turned on abruptly. Thus, the driving current of the laser diode 107 can rise abruptly.

Furthermore, by providing a resistor 110, excess charge of the NPN transistor 108 can be discharged to the ground, whereby more differential current addition can be performed. Furthermore, by providing a diode 109,  
10 when the input terminal 113 is turned to be a "Low" level, a base potential of the NPN transistor 108 can be clamped.

Still furthermore, the driving current 15, the differentiation circuit 16, and the V-I conversion circuit 17 include a NPN transistor 114 and a driving circuit 119. An emitter of the NPN transistor 114 is connected to an input  
15 terminal of the input PchMOS transistor 105 constituting the mirror circuit of the PchMOS transistor, a collector thereof is connected to a power source terminal 118, and a base thereof is connected to one electrode of the capacitor 117. An output terminal of a driving stage in the driving circuit 119 is connected to the other electrode of the capacitor 117.

In the above-mentioned configuration, when the switch 104 is opened, an input terminal of the driving circuit 119 is turned to be a logic "H" level. The NPN transistor 114 is supplied with a base current as a differentiated current through the capacitor 117, whereby the NPN transistor 114 is turned  
20 on. An emitter current of the NPN transistor 114 abruptly increases a gate potential of the input PchMOS transistor 105 constituting the mirror circuit of the PchMOS transistor, and the mirror circuit of the PchMOS transistor is turned off abruptly. Consequently, the driving current of the laser diode 107 can fall abruptly.  
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Furthermore, by providing a resistor 116, excess charge of the NPN transistor 114 can be discharged, whereby more differential increase in a gate potential can be performed. Furthermore, by providing a diode 115, when  
30 the input terminal 120 is turned to be a "Low" level, a base potential of the NPN transistor 114 can be clamped.

FIG. 3 is a timing chart showing a signal waveform of each portion in the circuit shown in FIG. 1. In FIG. 3, reference numeral 200 denotes a  
35 control signal waveform of the switch 104, 201 denotes an input current waveform of the laser diode drive current amplifier 10, 202 denotes an output

voltage waveform of the differentiation circuit 12, 203 denotes an output current waveform of the pull-in type V-I conversion circuit 13, 204 denotes an output voltage waveform of the differentiation circuit 16, 205 denotes an output current waveform of the push-out type V-I conversion circuit 17, and  
5 206 denotes a laser diode drive current waveform.

In the above embodiment, the configuration using the mirror circuit of the PchMOS transistor and the NPN transistor have been illustrated and mentioned. However, it is apparent that the same effects can be obtained even in the configuration using the mirror circuit of the NchMOS transistor  
10 and the PNP transistor.

Thus, according to the present embodiment, a current is added differentially in synchronization with the addition of an original input current to an amplifier of an input current, whereby the rising time of a laser diode drive current is shortened. Furthermore, by differentially increasing a  
15 gate potential of an input PchMOS transistor constituting a mirror circuit of a transistor in synchronization with the disconnection of an input current, the falling time of a laser diode drive current can be shortened.

As described above, according to the present invention, the rising time and the falling time of a laser diode drive current can be shortened in a  
20 range from a small current region to a large current region of the laser diode drive current.

The invention may be embodied in other forms without departing from the spirit or essential characteristics thereof. The embodiments disclosed in this application are to be considered in all respects as illustrative  
25 and not limiting. The scope of the invention is indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.